RECTANGULAR BRICARD MECHANISM

Figure 1 shows a 6-bar rectangular Bricard mechanism. All the links in the assembly are connected with revolute joints and have length l = 1 m, a uniformly distributed mass m = 1 kg, and a square cross section of width r = 0.1 m. This system is proposed as an example of redundantly constrained systems. The Bricard mechanism is redundantly constrained for the entire range of its motion. Moreover, the redundant constraint cannot be a priori identified, as the subset of constraint equations which are linearly dependent changes with the configuration of the system.

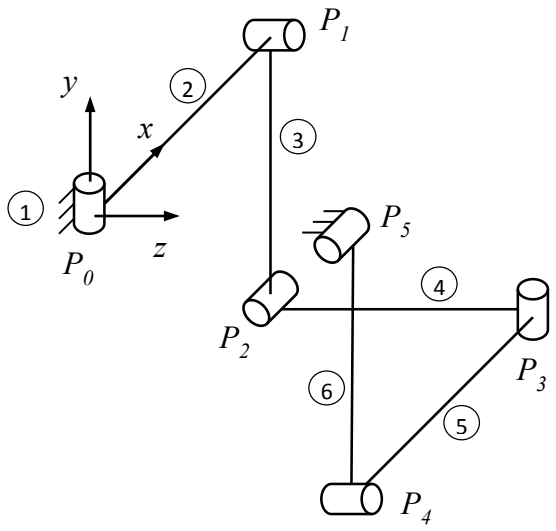

Figure 1: A rectangular, 6-bar Bricard mechanism

Point	x	y	z	Joint axis
P_0	0	0	0	y
P_1	l	0	0	z
P_2	l	- l	0	x
P_3	l	- l	l	y
P_4	0	- l	l	z
P_5	0	0	l	x

Table 1: Initial coordinates and orientations of the revolute joints of the mechanism

The system moves under gravity effects (-9.81 m/s^2 along the global y axis) from the initial position shown in the figure, in which link 2 is aligned with the global x axis. For this initial configuration, the position and orientation of each revolute joint is provided in Table 1 and all the velocities are zero. The total time of simulation is 10 s. Figure 2 shows the x, y, and z coordinates of point P_2 during motion.

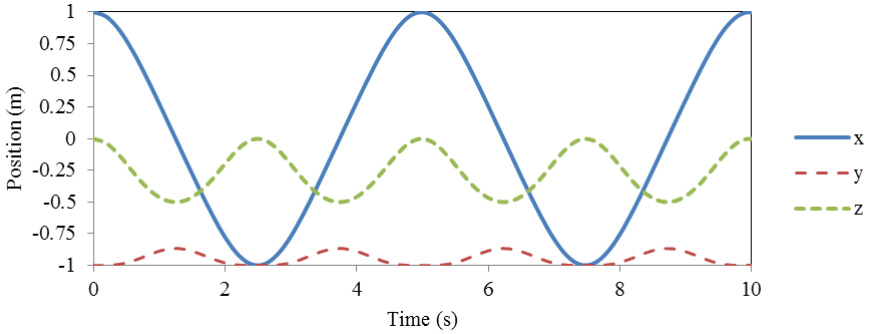

Figure 2: Time-history of the x, y, and z coordinates of point P_2

Figure 3 shows the evolution of the total energy of the system and the violations of the constraints at position and velocity levels during the simulation. The constraints violation is the norm of the array of constraints at the corresponding level (configuration or velocities). The total energy is obtained as the sum of the kinetic and potential energy of the mechanism, taking the initial potential energy as reference, so that the energy value to be conserved during the simulation is zero. The error of the simulation will be considered as the maximum drift of the energy from its theoretical null value.

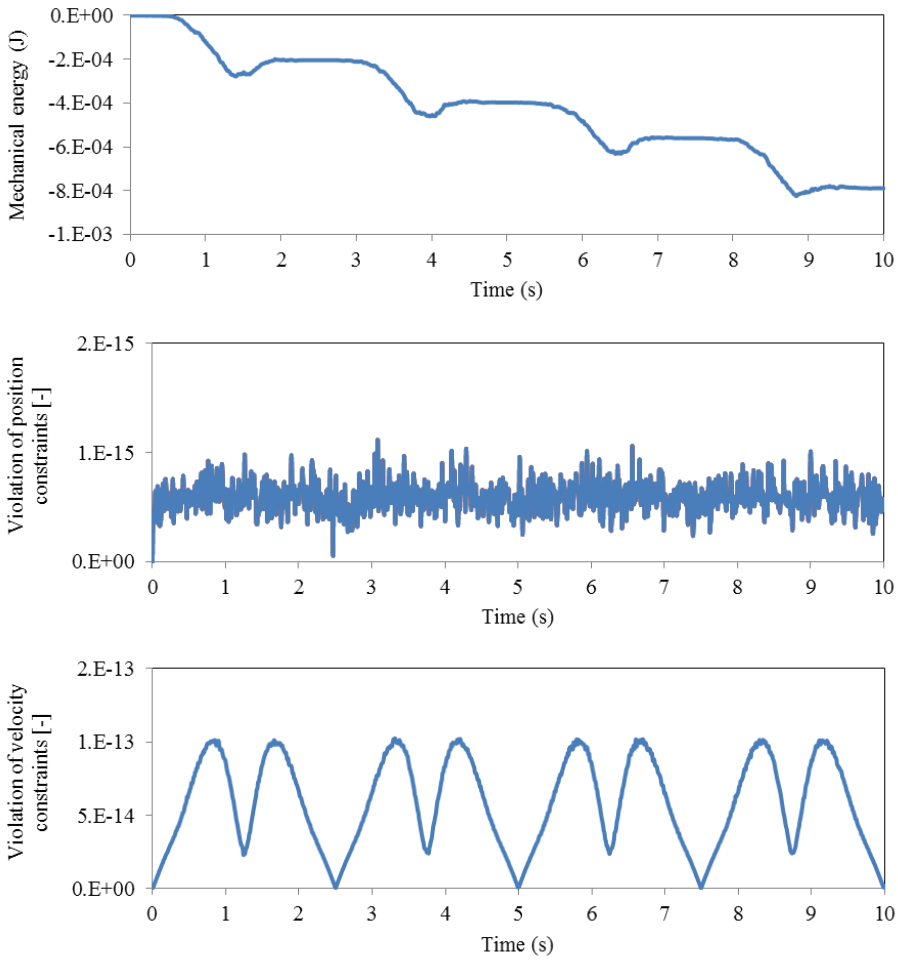

Figure 3: Time-history of the mechanical energy and the violation of constraints at the configuration and velocity levels

The objective of this benchmark problem is to carry out the simulation of the motion in the minimum CPU time, while keeping the maximum drift of the total energy away from the zero reference value below 0.001 J.

A reference text file with the results is available, for comparison purposes. The file is composed of seven columns. The first one represents the simulation timestamp, from 0 to 10 s. The second, third, and fourth columns contain the x, y, and z coordinates of point P_2 during motion. The fifth one is the mechanical energy of the system, and the last two ones represent the violation of constraints at the configuration and velocity levels.